TROPHIC RELATIONSHIPS AMONG COLORADO PIKEMINNOW (*PTYCHOCHEILUS LUCIUS*) AND ITS PREY IN THE SAN JUAN RIVER

(Scope of Work for FY 2004)

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Activities for FY 2004: The scope of work (SOW) and budget for FY 2004 are within this study plan for the entire study. Work to be accomplished during FY 2004 corresponds to Year 2 of the Study Plan. In FY 2004, we will conduct experiments that address Objectives 3 and 4, listed on page 6. The total budget of $51,000 for FY 2004 is detailed on page 19.

<u>BACKGROUND</u> An essential element of restoration or recovery of an endangered species, such as Colorado pikeminnow (*Ptychocheilus lucius*), is a thorough understanding of the relative importance of factors that have contributed to its decline. Various studies (e.g., Holden and Wick 1992, U.S. Fish and Wildlife Service 1990, Platania et al. 1991) have demonstrated that altered flow regimes, habitat modifications, range fragmentation, and establishment of numerous nonnative fish species have contributed to the imperiled status of Colorado pikeminnow. To enhance survival of the species, efforts have been made to remove or ameliorate factors identified as causing its decline. In addition, augmentation of extant populations by stocking hatchery-reared fishes has been undertaken in the San Juan River. All efforts to improve the status of Colorado pikeminnow by increasing its abundance implicitly assume there is an adequate prey base. However, considering the dramatic changes to the prey assemblages in this system, there is no clear evidence that adequate prey is available.

In the San Juan River, the historical prey base of Colorado pikeminnow was composed mainly of soft-rayed cyprinids and catostomids; other fishes such as mottled sculpin (*Cottus bairdi*) and cutthroat trout *(Oncorhynchus clarki*) occurred mainly in habitats upstream of those occupied by Colorado pikeminnow. Based upon their current distribution throughout warmwater reaches of the San Juan River and their high abundance (Gido et al. 1997, Gido and Propst 1999, Propst and Hobbes 2000), speckled dace (*Rhinichthys osculus*), flannelmouth sucker (*Catostomus latipinnis*), and bluehead sucker (*Catostomus discobolus*) were likely important prey for Colorado pikeminnow. Although currently rare in the San Juan River, roundtail chub (*Gila robusta*) and razorback sucker (*Xyrauchen texanus*) were more common historically (Tyus et al. 1982) and thus potential prey of Colorado pikeminnow. In the past 100 years, over 20 nonnative fishes have become established in the San Juan River; some are common and generally distributed, but others are rare (Bestgen 2000). Common and widespread nonnative fishes include red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), and channel catfish (*Ictalurus punctatus*). Although other ictalurids (e.g., *Ameiuus* spp.), in addition to channel catfish, and centrarchids are established in the San Juan River, none are common (Propst and Hobbes 2000, Ryden 2000).

Colorado pikeminnow begin to consume fish at an early age and small size (Vanicek and Kramer 1969). As an individual increases in size, its potential prey likewise increases in size. To some extent, prey availability is mediated by the habitat occupied by different life stages of Colorado pikeminnow. Young (<1 yr) and small (<100 mm TL) individuals that primarily inhabit low-velocity habitats, such as backwaters, prey largely upon syntopic species such as larvae or young of large-bodied species (e.g., roundtail chub and flannelmouth sucker). As Colorado pikeminnow grow, and move from low-velocity into main channel habitats, the size range and variety of prey likely increase, typical of piscivorous fishes (Gerking 1994). At this point, an individual's gape dimensions and where it forages are major factors limiting prey size and variety. In primary channel habitats typically occupied by adult Colorado pikeminnow, its primary prey species historically were speckled dace and sub-adults and adults of roundtail chub, flannelmouth sucker, bluehead sucker, and razorback sucker. Although speckled dace, flannelmouth sucker, and bluehead sucker are currently common in the San Juan River, historical data are insufficient to determine whether abundance of any, or all, have declined, increased, or remained constant. Roundtail chub and razorback sucker, however, are now less common than historically (Tyus et al. 1982, Platania et al. 1991).

Three factors probably were major determinants of prey consumed by Colorado pikeminnow: habitat occupied, gape dimensions, and prey encountered. To the extent that habitat of a potential prey species differed from that typically occupied by Colorado pikeminnow, the less likely it was to be preyed upon. For example, because speckled dace occurred mainly in riffles and adult Colorado pikeminnow typically occupied deeper and less turbulent habitats, dace were not likely primary prey items of pikeminnow. For sub-adult Colorado pikeminnow, however, speckled dace may have been an important prey species. In addition, the small-bodied speckled dace (adult size <120 mm TL) are presumably more energetically costly than larger prey species because of the large number necessary to maintain basal metabolic demands. Moreover, prey items of

Colorado pikeminnow may be dependent on its hunting tactics. If it is an ambush predator, habitat occupied largely determined what it would most likely encounter and therefore consume. Alternatively, if it stalks or actively hunts prey and moves among habitats, diversity of prey likely increased.

Introduction and establishment of nonnative fish species, both caused the decline of native fish species (via competitive interactions or predation by nonnatives) and the addition of potential prey items for native predators. Whereas these nonnative fishes may serve as prey for Colorado pikeminnow, they may be better adapted to escape predation than native prey species because they evolved in eastern systems with higher densities of predators. Thus, it is unclear what effect the establishment of nonnative species and decline of native prey species had or will have on populations of Colorado pikeminnow. Has the introduction of nonnative species increased, decreased, or had no effect on the forage base? Or, as assemblage structure and composition changed, has Colorado pikeminnow foraging success declined, increased, or remained the same? *A key question is whether changes in prey base affected viability of Colorado pikeminnow in the San Juan River and if these changes are likely to impair success of augmentation efforts?*

We propose a series of field experiments, using recently developed stable isotope tracer technology, to evaluate relative use of native and nonnative prey species by Colorado pikeminnow. This study will quantify the dietary importance of commonly occurring species (e.g., native flannelmouth sucker, bluehead sucker, and speckled dace and nonnative common carp, red shiner, fathead minnow, and channel catfish) under controlled and existing “natural” conditions. In addition, roundtail chub will be used in experiments to determine if Colorado pikeminnow preferably forage on this species, which was once abundant in the San Juan River. Finally, our results will complement existing bioenergetics models (Lamarra and Miller) by quantifying relative importance and caloric content of different tropic levels.

Recent developments in mass spectrometry have enabled the use of naturally occurring stable isotopes of nitrogen (^{15}N) and carbon (^{13}C) to determine trophic position and trace pathways to determine ultimate energy sources. Ratios of $^{15}N/^{14}N$ are typically low in naturally occurring elements. Stable isotopes of nitrogen (^{15}N) are particularly helpful in evaluating trophic position of organisms because individuals that feed high in the food web (i.e., predators) tend to be enriched with heavy ^{15}N, which accumulates during protein synthesis at a faster rate than the lighter ^{14}N isotope. Stable isotopes also provide information on the source(s) of energy. For example, Cherel et al. (2000) were able to establish the breeding origins of seabirds by analyzing stable isotope signatures in feathers. McCarthy and Waldron (2000) were able to differentiate freshwater-resident and sea-run migratory brown trout based on changes in stable isotopes of N and C in their tissues. Martinez et al. (2001) characterized the isotope ratios of fishes in the Colorado River basin and suggested that isotopes may be helpful in determining if off-channel ponds were the source of nonnative fishes. Thus, naturally occurring stable isotope ratios can be used to determine the origin of energy assimilated by organisms, which compliments traditional food habits studies that only give a snap-shot of food items consumed at a particular moment. In addition, components of natural systems can be enriched with ^{15}N and then those molecules can be followed through the system to quantify energy transfer (e.g., Dodds et al. 2000). We propose to use this technology combined with a series of field experiments to evaluate the relative contribution of potential prey, including roundtail chub, to Colorado pikeminnow in the San Juan River.

Below, we describe a series of field and laboratory studies and experiments to examine the relative importance of common native and nonnative fishes in the diet of Colorado pikeminnow. The first phase of the proposed study will be to identify caloric content and signatures of stable isotopes of N and C at all trophic levels in the San Juan River (organic sediments through "top" predator) in each geomorphic reach of the river (Farmington to Lake Powell). The next phase of the study will quantify differences in prey behavior among native and nonnative species and vulnerability of these species to consumption by Colorado pikeminnow using a combination of artificial streams and field experiments. We also will use ^{15}N tracers during these experiments to positively identify native prey species of Colorado pikeminnow.

The overarching goal of this study is to *assess the capability of current San Juan River prey base for maintenance of viable Colorado pikeminnow populations*. Specific objectives/goals of the study are:

1) Characterize prey base of Colorado pikeminnow and linkages with lower tropic levels by determining stable isotope signatures ($\delta^{15}N$ and $\delta^{13}C$) of the biotic assemblages in the San Juan River for six geomorphic reaches of the river (Farmington to Lake Powell).

2) Work in conjunction with Lamarra and Miller to incorporate prey suitability, trophic relationships, and caloric content of lower trophic groups into bioenergetics models. Quantify caloric content for different trophic levels in the San Juan River by reach to parameterize bioenergetics models for Colorado pikeminnow.

3) Determine if Colorado pikeminnow use nonnative prey as efficiently as native prey by conducting foraging experiments in artificial streams located at the Konza Prairie Biological Station (KPBS), Kansas and in field enclosures in secondary channels of the San Juan River.

4) Quantify the use of specific prey items by Colorado pikeminnow by using $\delta^{15}N$ labeled roundtail chub or other fish species in field enclosure experiments.

STUDY DESIGN

Stable isotope signatures and caloric content—To establish baseline data on carbon and nitrogen isotope signatures of the fish assemblage in the San Juan River, we will collect and analyze samples from fishes and potential prey items from the six geomorphic reaches of the San Juan River from Farmington to Lake Powell beginning in 2003. In addition, we will analyze these samples for caloric content. Both the stable isotope analysis and the caloric data will help quantify the feeding relationship and energy requirements of Colorado pikeminnow and its prey. This aspect of the study will complement the bioenergetics modeling of Lamara and Miller and thus, we will work to coordinate our sampling and analysis to accommodate those models.

Collections of fish tissue will be made in conjunction with ongoing monitoring programs to facilitate capture of fishes. Small-bodied fishes will be collected whole, whereas tissue plugs or fin clips will be taken from large-bodied native and nonnative fishes. This information will allow us to characterize trophic position of each species in the assemblage and possibly determine specific prey items of native (Colorado pikeminnow) and nonnative (channel catfish) predators. These data also will provide essential information on naturally occurring levels of these isotopes to compare with the experiments described below.

Tissue samples from fishes and other organisms from lower trophic levels will be frozen in the field and brought to the laboratory, thawed, dried at 50^{o}C for 48hr and ground to a powder with a mortar and pestle. Ground samples will be analyzed in the Stable Isotope Mass Spectrometry Laboratory (SIMSL) in the Division of Biology at Kansas State University (KSU) using a ThermoFinnigan Delta Plus mass spectrometer. Stable isotope ratios will be calculated in the standard notation:

$$\delta^{15}N = [{}^{15}N/{}^{14}N_{sample}/{}^{15}N/{}^{14}N_{standard}) - 1 \times 1000$$
$$\delta^{13}C = [{}^{13}C/{}^{12}C_{sample}/{}^{13}C/{}^{12}C_{standard}) - 1 \times 1000$$

Values will be expressed on a per mil (‰) basis. Because carbonates are known to bias isotope ratios of carbon, a separate aliquot will be taken from each sample, acidified to remove carbonates and then analyzed for carbon isotope ratios as described above. A pilot study, in which samples from the San Juan River community were taken in October 2001 demonstrated our ability to process samples necessary to complete the proposed experiments using the facilities at KSU. Although we did not collected samples from adult native fishes, preliminary results suggest a high degree of overlap in energy acquisition between juvenile natives and adult nonnative fishes (Figure 1). In addition, spatial variation in δ^{13}C signatures between backwaters (Green algae and chironomids) and main-channel habitats suggest a high potential to determine the relative importance of different habitats on consumer species.

Caloric content of fish, invertebrate, and plant material will allow us to evaluate the potential quality of different resources bases for Colorado pikeminnow. Measurements will be made with a Parr semi-microbomb calorimeter. For fishes, only muscle tissue from the dorsal region will be used. All samples will be homogenized as described as above and pressed into a pellet for combustion in the calorimeter.

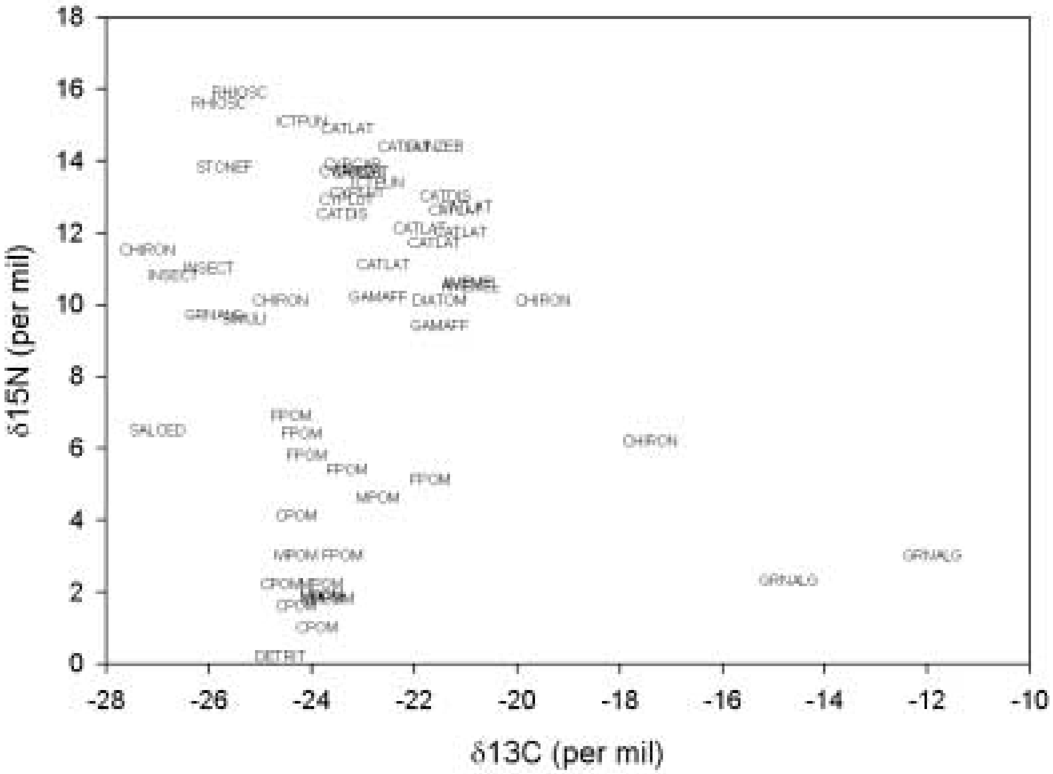

Figure 1. Stable isotope signatures for various components of the aquatic community in the San Juan River between RM 120 and RM 90. Abbreviations are as follows: Labels for fishes include the first three letters for the genus plus the first three letters of the specific epithet; FPOM, MPOM, and CPOM = fine, medium, and coarse particulate organic matter, respectively; CHIRON = chironomid; STONEFL = Stoneflies; GRNALG = green algae; SIMULI = Simulids; DETRIT = Detritus; SALCED = Salt Cedar; INSECT = various insects.

Artificial stream experiments

A combination of artificial streams and field enclosures will be used to quantify the importance of native and nonnative fishes as prey by Colorado pikeminnow. Artificial streams are located at the KPBS in Kansas and have been designed to match the stream units that have been successfully used in previous experiments at the University of Oklahoma (Gido et al. 1999, Gido and Matthews 2001, Matthews et al. 2001). Each stream will be configured to have two pools connected by a riffle (Figure 2) and mimic natural pool and riffle habitats. These systems should provide sufficient structural heterogeneity to provide cover for experimental fishes. Substrate will be a mixture of cobble, gravel, sand, and silt to match conditions in the San Juan River (i.e., predominately sand and cobble substrate). This experiment will examine changes in behavior of the various prey fishes when in the presence of a caged Colorado pikeminnow. In addition, we will release the pikeminnow and determine its foraging efficiency on the different prey species. Our working hypothesis is that nonnative species will alter their behavior more than native species in the presence of Colorado pikeminnow and also be less vulnerable to predation than the native species.

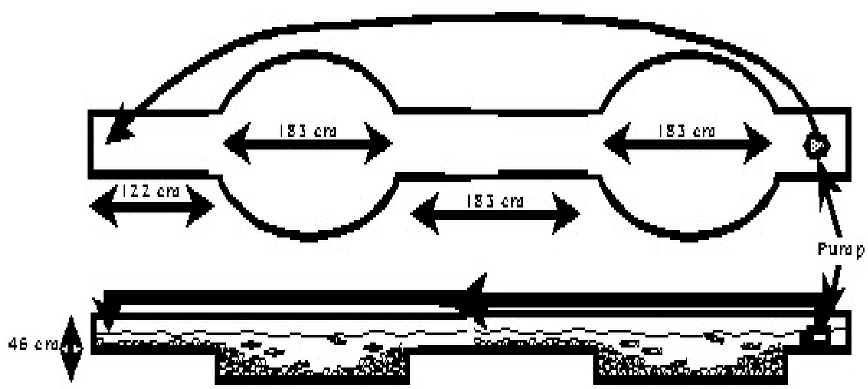

Figure 2. Configuration of artificial stream to be used to test prey response to and foraging efficiency of Colorado pikeminnow.

Prey behavior trials –In this experiment we will monitor the behavior of three native species (speckled dace, flannelmouth sucker, and roundtail chub) and two nonnative species (red shiner and fathead minnow) before and after the introduction of a caged pikeminnow into the streams. Five replicate trials will be run for each species using different fishes. The prey fish will be stocked at moderate densities (sensu Gido and Propst 1999) in the streams, 24 hr before the introduction of the pikeminnow, to allow them time to "adjust" to the system. After this period, habitat use of each individual will be characterized. Next, one caged pikeminnow will be placed into a randomly selected pool. Habitat use of the prey species will be measured one hour after the introduction of the pikeminnow. Habitat use measurements will include location in the water column (surface, bottom, etc.), mesohabitat (pool or riffle), proximity to caged predator, and activity rates (e.g., feeding, swimming, resting).

Predation efficiency - Additional experiments will be conducted to determine the relative predation efficiency of pikeminnow on the various prey species. Stream configuration, stocking densities, and acclimation period will be the same as above. However, in these trials, the pikeminnow will be released and allowed to forage on the various prey species. The pikeminnow will be removed after 24 hours and all fish will be seined from the streams to determine the number consumed by the pikeminnow. Pikeminnow will be starved for 48 hr prior to the foraging efficiency experiment.

For all experiments, the fishes will be kept at a holding facility at Kansas State University and facilities will be modified to preclude accidental escape of San Juan fishes in the Kansas River system. For this experiment and those described below, all the appropriate permits necessary to work with endangered species and the transfer of nonindigenous fishes will be obtained beforehand.

Field experiment

Results from the experimental stream studies will be complimented with field enclosure experiments to evaluate our ability to scale our results up to natural systems. Field enclosures will allow us to recapture Colorado pikeminnow, prey species, and nonnative predators at the end of the experiment. For these experiments, 10 mm-mesh plastic netting will be used to block six ca.100-m reaches in a secondary channel of the San Juan River. Previous studies (e.g., Gido et al. 1997, Gido and Propst 1999) found that 100m reaches of San Juan River secondary channels contained a diverse array of habitats including pools, riffles, eddies and backwaters. Thus, these reaches should adequately represent major habitats available to pikeminnow and their prey. Reaches will be selected to have similar physical habitat features (e.g., depth, flow and large woody debris). Each reach will be sufficiently long (100 m) so that fishes behave normally and predation rates by Colorado pikeminnow will not be artificially high. After block nets (constructed of wire mesh and secured to the substrate with rebar) are in place, each reach will be sampled with three or more passes of a seine and DC-pulsed backpack electrofisher to quantify species present in the experimental reaches. All captured fish will be identified, counted, and released back into the reach from which they were captured. Muscle plugs will be taken from 30 to 50 individuals of each species for isotope characterization. If there are major differences in assemblage structure among enclosed reaches, we will remove or add fish to facilitate comparisons among reaches. After fish are sampled, three of the six reaches will be stocked with 5 sub-adult pikeminnow (200 to 350 mm TL). Prior to stocking, these individuals will be marked with a PIT tag and a tissue plug will be taken for isotope analysis. By monitoring changes in abundance of all species relative to enclosures without Colorado pikeminnow, we will be able to quantify changes in mortality rates of nonnative prey species as well. Captive-reared and nitrogen –labeled roundtail chub will be placed in one exclosure during each trial.

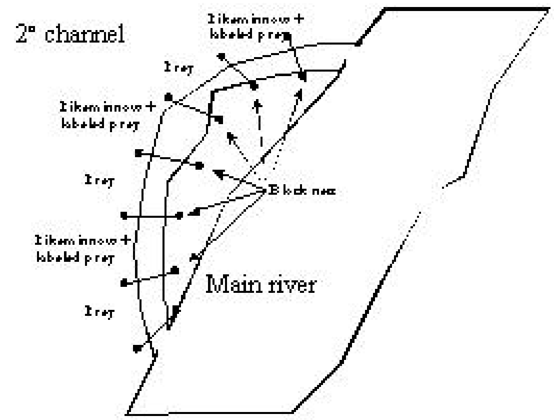

Figure 3. Design of field enclosure experiments to be conducted in San Juan River secondary channels.

We will attempt to run the experiment twice a year for two years to account for temporal variation in abiotic and biotic conditions. The length of each experimental run will be approximately two weeks, assuming this will be adequate time to uptake sufficient ^{15}N for detection, as determined from laboratory experiments (see below). A field crew consisting of at least two individuals will be on site during each experiment to monitor field conditions and clean debris and maintain block nets. At the end of the experiment, a combination of seining and DC-pulsed backpack electrofishing will be used to capture all stocked fishes from each reach. A sample of dorsal muscle tissue will be taken from each pikeminnow, frozen and returned to the laboratory for analysis. Channel catfish and any other predators captured during this study will be sacrificed for tissue samples and analysis of stomach contents. All other fishes captured will be identified, measured, and released, with the exception of labeled prey species, which will be preserved in 10% formalin and returned to the laboratory to characterize growth during the experiment.

During Year 1 of this study, we will construct block nets on one secondary channel to evaluate the feasibility of the field experiments. If we are able to contain fishes for two weeks, we will proceed with the experiments the following year.

Field trials will be conducted from cessation of spring runoff (late June-early July) through early autumn (late September) during summer 2004 and 2005. The two field experiments will be conducted within a six week period; the second experiment will occur two weeks after completion of first experiment. Information and insights gained during the first run will be considered in making changes to the experimental design in subsequent trials.

Probability of success will depend on the frequency of flood events that may destroy or damage exclosures. An evaluation of historic flows from the USGS gauging station at the Four Corners Bridge indicates we have a very high likelihood of success. We selected a likely starting date of 1 July and examined previous discharge records between 1978 and 2000 to determine how many years there would have been a significant flow event during a two week period after 1 July. In three of the 23 years examined, the flow in the river doubled in the two weeks following 1 July, suggesting a 13% chance that our experiment would be ruined. However, if we attempt these experiments during two years, or twice each year, the chances of a flood of sufficient magnitude to destroy or damage exclosures drops to 1.7 % or less. Moreover, we will closely monitor weather forecasts to increase our chances of success.

Laboratory study to evaluate use of $\delta^{15}N$ as a tracer

In conjunction with the artificial stream and field experiments, we will evaluate the feasibility of using ^{15}N labeled prey items to confirm consumption of particular prey species by a predator. This will allow us to separate losses of prey items to natural mortality from those consumed by pikeminnow. Brine shrimp cultures will be reared at KSU and their tissue will be ^{15}N enriched by feeding them algae grown in ^{15}N labeled ammonium chloride. The ^{15}N labeled shrimp will be stockpiled in a freezer and used to enrich the tissues of captive native San Juan fishes (roundtail chub, speckled dace, and flannelmouth sucker). To evaluate the uptake efficiency and tissue enrichment of the ^{15}N in the prey, tissue samples from five individuals of each species will be taken one, two, and three weeks after the initiation of a ^{15}N enriched brine shrimp diet and analyzed for ^{15}N using procedures described above. To further evaluate the ability of the ^{15}N label in minnows and suckers to be transferred to a predator, we will feed the ^{15}N enriched fish to pikeminnow at a rate of one individual per day for one, two, and three week periods and measure ^{15}N accumulation in pikeminnow muscle tissue from five individuals after different feeding durations. We will use the results from this study to adjust the amount of time necessary to feed prey fishes a ^{15}N labeled diet and the number of ^{15}N labeled prey fishes that are necessary for the pikeminnow to consume to detect their consumption in the field. In addition, this will allow us to assess our ability to use ^{15}N concentration in pikeminnow tissue to quantify the biomass of prey consumed. That is, individuals that consume a greater quantity of enriched prey should have higher concentrations of ^{15}N in their tissue.

Data analysis

Differences in isotope signatures among geomorphic reaches will first be assessed using biplots of $\delta^{15}N$ and $\delta^{13}C$ signatures. Significant differences among reaches for each species will be assessed using Analysis of Variance (ANOVA) with post hoc corrections for multiple comparisons. ANOVA also will be used to evaluate difference in prey behavior and prey mortality rates in the presence or absence of Colorado pikeminnow in artificial stream and field experiments. Because the field experiments will be repeated over time (i.e., two years), year of experiment will be included as a blocking variable. Finally, paired t-tests will be used to evaluate differences in $\delta^{15}N$ in Colorado pikeminnow tissue before and after field experiments stocked with enriched native fishes. This will allow us to confirm the consumption of different prey species under natural conditions.

SIGNIFICANCE OF PROPOSED RESEARCH

Recovery of endangered species often depends on maintaining important linkages of imperiled species with other components of the ecosystem. Hydrology and fish assemblage structure has been drastically altered in the San Juan River. Thus, recovery efforts to increase populations of Colorado pikeminnow may depend on restoring both a natural hydrology and other native species populations, such as roundtail chub. The proposed research will quantify the use of both native and nonnative prey species in the diet of Colorado pikeminnow. In addition, we will generate energy density information that can be used to refine bioenergetics models that estimate carrying capacity of the system. This information will strongly influence management decisions to either supplement native prey species or eradicate nonnative species. Moreover, by examining the consumption of prey items by nonnative predators (e.g., channel catfish), we can evaluate the potential competitive interactions among these fishes. This proposed study, if conducted, will provide information necessary to achieve SJRRIP Long Range Plan Objectives 4.4, 5.3.6, and 5.4.3. The use of manipulative field experiments will build upon existing correlative data (e.g., monitoring programs and carrying-capacity modeling efforts) to characterize the interactions of Colorado pikeminnow with native and nonnative fishes in the San Juan River, and to provide information that enables implementation of adaptive management strategies to recover Colorado pikeminnow in the San Juan River.

SCHEDULE

The first year of the proposed research will focus on collecting tissue samples for isotope signatures and caloric content. This information will help define the trophic interaction of Colorado pikeminnow and its prey resources. In addition, we will conduct several pilot experiments to assess the feasibility of the proposed field experiments. Thus, at the end of the first year, we will evaluate the likelihood that forthcoming experiments will be successful. If it is determined, based on pilot projects, that the experiments have a low probability of success we will either modify the proposed activities accordingly, or terminate the experiments and spend a second year finalizing a written report of the first year's results.

Timeline
June 2003 – May 2004: Collect samples from six geomorphic reaches of the San Juan River to characterize stable isotope signatures and caloric content of fishes and resource bases to evaluate sources of energy. Conduct pilot laboratory experiments at KSU, capture and rear fish to be ^{15}N enriched, select study secondary channel.
Conduct pilot experiments to evaluate and refine the feasibility of using blocked sections of secondary channels as replicates for field experiments.

Jul. 2004 – Sep. 2004: Conduct first year of field experiments (two trials).

Oct. 2004 – Nov. 2004 Conduct prey behavior and predator consumption experiments in artificial streams

Nov. 2004 – July 2005: Laboratory and data analyses

Jul. 2005 – Sept 2005: Conduct second year of field experiments (two trials).

Oct. 2005 – Nov. 2005: Conduct second year of prey behavior and predator consumption experiments in artificial stream.

Nov. 2005 – Dec. 2006: Complete data analysis and synthesis. Draft and complete project completion report.

Facilities and Equipment available at Kansas State University
Artificial Stream system located at Konza Prairie Biological Station (12 riffle/pool units are currently in place and another 12 units are expected to be running by December 2002)

Wet lab (1100 ft^2) with fiberglass holding tanks and carbon filter water conditioning system

ThermoFinnigan Delta Plus mass spectrometer

Parr semi-microbomb calorimeter w/2 bombs

Large capacity drying oven

Ohaus digital analytical balance

Compound and dissecting microscopes

BUDGET

2003 – 2004 (YR1):	Personnel	
	KSU (research technician, 1 month summer salary for Gido, undergraduate assistant to run calorimeter)	30,000
	NMDG&F	5,000
	Per diem and travel	3,000
	Equipment and supplies (Chemicals, seines, block nets, isotope and bomb analysis, etc.)	7,000
	Overhead (20% of KSU budget)	8,000
	Total FY 2003	53,000
2004 – 2005 (YR2)	**Personnel**	
	KSU (research technician, 1 month summer salary for Gido)	**25,000**
	NMDG&F	**10,000**
	Per diem and travel	**5,000**
	Equipment and supplies (Chemicals, seines, block nets, isotope analysis, etc.)	**5,000**
	Overhead (20% of KSU budget)	**6,000**
	Total FY 2004	**$ 51,000**
2005 – 2006 (YR3)	Personnel	
	KSU (research technician, 1 month summer salary for Gido)	25,000
	NMDG&F	10,000
	Per diem and travel	5,000
	Equipment and supplies	5,000
	Overhead (20% of KSU budget)	6,000
	Total FY 2005	51,000
	Grand Total Budget	**$155,000**

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